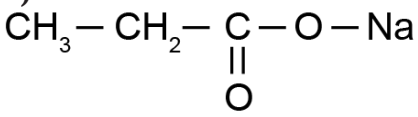
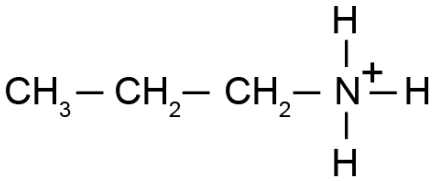
ANSWERS: Types of Reactions

1) All three reactions are substitution reactions. In all three reactions an atom or group of atoms is being replaced with another atom or group of atoms.
In **Reaction One;** a Br atom replaces an H atom. UV light is necessary.
In **Reaction Two;** a Cl atom replaces the OH group. No conditions are required.
In **Reaction Three;** the Cl atom is replaced by NH_2. No conditions are required.

Two layers form in Reaction One as hexane is non-polar and the product (bromohexane) is effectively also non-polar. The water from the bromine water is polar and therefore the non-polar organic reactant and product will not dissolve in the water; because of this, two layers form as this polar and non-polar layer do not mix.

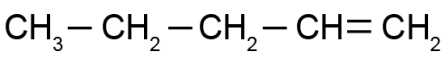
2)





When propanoic acid reacts with sodium carbonate, an acid-base reaction occurs in which sodium propanoate, water and carbon dioxide are formed. It is acid-base because the propanoic acid donates a proton, forming the propanoate ion.
When propanamine reacts with HCl or H_2SO_4, acid-base reactions occur. Amines are bases and as a result amines accept protons from acids. In these two reactions both sulfuric acid and hydrochloric acid donate protons to the amine to form organic salts.
When propan-1-ol reacts with HCl, a substitution reaction occurs; in this reaction the Cl from HCl replaces the –OH group from propan-1-ol, forming a haloalkane.
The reaction between conc. H_2SO_4 / heat, and propan-1-ol is an elimination reaction because an –OH group attached to C1, and a hydrogen atom from C2 are both removed from the organic molecule. A double bond forms between C1 & C2, with the elimination of water, forming propene.

3) It is an elimination reaction because two atoms are being removed from the molecule and a double bond is being formed between the carbon atoms from which the atoms have been removed.



4) Reaction with PCl_5 is a substitution reaction. The hydroxyl group (–OH) is replaced by a chloro group (–Cl).

The product is $CH_3CH_2CH_2CH_2Cl$

The functional group in the product is a chloro group / chloroalkane (haloalkane).

Reaction with acidified dichromate is oxidation as the alcohol is oxidised to a carboxylic acid.

The product is $CH_3CH_2CH_2COOH$

The functional group in the product is carboxylic acid.

Reaction with concentrated H_2SO_4 is an elimination reaction. A hydrogen atom and the –OH group on (adjacent) carbon atoms are removed forming a (carbon-to-carbon) double bond.

The product is $CH_3CH_2CH{=}CH_2$

The functional group in the product is a (carbon-to-carbon) double bond / alkene.

5) Chloroethane reacts with $KOH_{(aq)}$ to form an alcohol in a substitution reaction; Cl is replaced by OH.
$CH_3CH_2Cl \rightarrow CH_3CH_2OH$

Chloroethane reacts with $KOH_{(alc)}$ to form an alkene in an elimination reaction; H and Cl removed / HCl formed.
$CH_3CH_2Cl \rightarrow CH_2 = CH_2$

Chloroethane reacts with NH_3(alc) to form an amine in a substitution reaction; Cl is replaced by NH2
$CH_3CH_2Cl \rightarrow CH_3CH_2NH_2$

6) (1) substitution.
(2) substitution.
(3) elimination.
(4) addition.

Molecules that undergo **substitution** reactions have carbon to carbon single bonds and form molecules with carbon to carbon single bonds. In a substitution reaction an atom or group of atoms is replaced by another atom or group of atoms.

Molecules that undergo **elimination** reactions have carbon to carbon single bonds and form molecules with carbon to carbon double bonds. In an elimination reaction two atoms or small groups are removed from a molecule forming a carbon to carbon to double bond.

Molecules that undergo **addition** reactions have carbon to carbon double bonds and form molecules with carbon to carbon single bonds. In an addition reaction the reaction involves breaking a double bond between the carbon atoms and forming a single bond in its place as well as forming two new single bonds.

Reactions (1) and (2) are both substitution reactions as the molecules have carbon to carbon single bonds. In (1) the hydroxyl group (–OH) is replaced by a chloro group (–Cl). In (2) the chloro group (–Cl) is replaced by the amine group ($–NH_2$).

Reaction (3) is an elimination reaction as the molecule has carbon to carbon single bonds and a double bond is formed when it reacts. A hydrogen atom and the hydroxyl group on adjacent carbon atoms are removed forming a carbon to carbon double bond.

Reaction (4) is an addition reaction as the molecule has carbon to carbon double bonds and the product has carbon to carbon single bonds. In this reaction the double bond breaks forming a single bond, a hydrogen atom attaches itself to one of the carbon atoms and a chlorine atom attaches itself to the other carbon atom.

7) $CH_3 – CH = CH_2$
Elimination

8) Reaction One
Reactant A – H_2O / H^+ Type – addition
OR H_2O / acid
OR concentrated H_2SO_4 then H_2O
OR dilute / aq H_2SO_4

Reaction Two
Reactant B – conc / c H_2SO_4 Type – elimination
OR Al_2O_3 / broken pottery

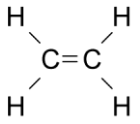
Reaction Three
Reactant C – bromine / Br_2 Type – substitution

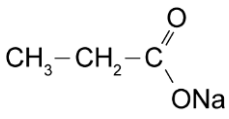
9) Addition – occurs in alkenes because they have double bonds. Ethene is an alkene so will undergo addition reactions. The chlorine (molecule) will add (across the double bond.)

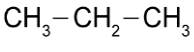
$CH_2 = CH_2 + Cl_2 \rightarrow CH_2Cl - CH_2Cl$

Substitution occurs in alkanes (because they have single bonds). Ethane is an alkane, so will undergo substitution reactions. One hydrogen atom will be removed from the molecule and one chlorine atom will take its place. UV light is required for the process.

$CH_3 - CH_3 + Cl_2 \rightarrow CH_2Cl - CH_3 + HCl$

10) a)  OR ethene elimination

b)  OR sodium propanoate acid-base

c)  OR propane addition

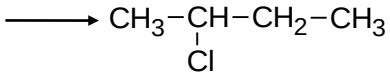
11) In both reactions, a colour change from purple to colourless will be seen as purple MnO_4^- /H^+ is reduced to Mn^{2+}.
(OR colour change from purple to brown precipitate if non-acidified MnO_4^-.)
Ethene will react to form a diol,
ethan-1,2-diol:

$$CH_2CH_2 \xrightarrow{MnO_4^-/H^+} CH_2(OH)CH_2(OH)$$

Ethanol will react to form a carboxylic acid, ethanoic acid:

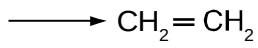
$$CH_3CH_2OH \xrightarrow{MnO_4^-/H^+} CH_3COOH$$

12) a)



Addition involves a small molecule (HCl) joining onto adjacent carbon atoms of an unsaturated molecule. The double bond breaks / molecule becomes less unsaturated / becomes saturated.

b)



Elimination involves the removal of two substituents / groups / H & OH / water / on neighbouring C atoms in a molecule. A double bond forms / forms an alkene / the molecule becomes less saturated.

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